

HIGH DATA RATE COAXIAL INTERCONNECT TECHNOLOGY BETWEEN
PRINTED WIRING BOARDS

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This patent application is a continuation-in-part of U.S. Patent Application No. 09/660,196, entitle "Technique for Coupling Signals Between Circuit Boards" which was filed on September 12, 2000 as a continuation-in-part of U.S. Patent Application No. 09/443,128, entitled "Zero Cross-Talk Signal Line Design", filed November 18, 1999, both of which are hereby incorporated by reference herein in their entirety. This application claims priority from Provisional Application Serial No. 60/246,598, filed on Nov. 8, 2000.

FIELD OF THE INVENTION

10 The present invention relates generally to the making of electrical signal connections between circuit boards and, more particularly, to a technique for electrically interconnecting signals between circuit boards.

BACKGROUND OF THE INVENTION

15 In many computer systems, electronic components are typically mounted on a plurality of circuit boards. These circuit boards, often referred to as daughterboards, are typically mounted on a motherboard so as to allow electrical

There are also space concerns associated with the use of conventional pin-and-box board-to-board connectors. That is, conventional pin-and-box board-to-board connectors typically have bulky mechanical shrouds which take up 20 valuable board and shelf space.

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In view of the foregoing, it would be desirable to provide a technique for making electrical signal connections between circuit boards which overcomes the above-described inadequacies and shortcomings. More particularly, it would be desirable to provide a technique for electrically interconnecting signals between circuit boards while eliminating problems associated with mechanical electrical connectors.

According to the present invention, a technique for electrically interconnecting a signal between a first circuit board and a second circuit board is provided. In one embodiment, the first circuit board has a first signal conductor or set of signal conductors formed therein, and the second circuit board has a second signal conductor or set of signal conductors formed therein. Also, the first signal conductor is shielded by a first electrically conductive shield, and the second signal conductor is shielded by a second electrically conductive shield. In

15 In accordance with still further aspects of the present invention, wherein the signal is a first signal, the first circuit board may have a third signal conductor formed therein, and the second circuit board may have a fourth signal conductor formed therein. The third signal conductor
20 may be shielded by a third electrically conductive shield, and the second signal conductor may be shielded by a fourth electrically conductive shield. Then, a third opening may

beneficially be formed in the third electrically conductive shield so as to expose the third signal conductor in the first circuit board. Also, a fourth opening may beneficially be formed in the fourth electrically conductive shield so as to expose the fourth signal conductor in the second circuit board. Further, the first circuit board and the second circuit board may beneficially be positioned such that the third opening and the fourth opening are aligned and a second signal propagating along the third signal conductor is electrically interconnected to the fourth signal conductor. Typically, the third electrically conductive shield is electrically connected to the first electrically conductive shield, and the fourth electrically conductive shield is electrically connected to the second electrically conductive shield.

In accordance with still further aspects of the present invention, the first circuit board may be a motherboard, and the second circuit board may be a daughterboard. The daughterboard is beneficially formed at least partially of flexible material so as to allow angular mating with the motherboard.

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In an alternate embodiment, the first circuit board has a first signal conductor formed therein, and the second circuit board has a second signal conductor formed therein, but only the first signal conductor is shielded by an electrically conductive shield. In this embodiment, the technique is realized by forming an opening in the electrically conductive shield so as to expose the first signal conductor in the first circuit board. The method is further realized by applying an electrically conductive adhesive, solder paste, or interposer/elastomer device surrounding the first opening and within the first opening. The first circuit board and the second circuit board are then positioned such that the first signal conductor and the second signal conductor are aligned through the opening and a signal propagating along the first signal conductor is electrically interconnected to the second signal conductor.

The present invention will now be described in more detail with reference to exemplary embodiments thereof as shown in the appended drawings. While the present invention is described below with reference to preferred embodiments, it should be understood that the present invention is not limited thereto. Those of ordinary skill in the art having

access to the teachings herein will recognize additional implementations, modifications, and embodiments, as well as other fields of use, which are within the scope of the present invention as disclosed and claimed herein, and with
5 respect to which the present invention could be of significant utility.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to facilitate a fuller understanding of the present invention, reference is now made to the appended drawings. These drawings should not be construed as
10 limiting the present invention, but are intended to be exemplary only.

Figure 1 is a perspective view of a conventional motherboard/daughterboard mounting configuration.

Figure 1A is a side cross-sectional view of a portion
15 of the conventional motherboard/daughterboard mounting configuration shown in Figure 1.

Figure 2A illustrates a fragmentary perspective view of a printed wiring board incorporating the invention for the case of single-ended interconnects.

20 Figure 2B is a cross-sectional view of Figure 2A illustrating typical construction.

Figure 8 is a cross-sectional view of an alternative embodiment of the invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENT(S)

In order to facilitate a fuller understanding of the present invention, reference is now made to the appended 5 drawings. These drawings should not be construed as limiting the present invention, but are intended to be exemplary only.

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To illustrate the concept of the present invention it is first ~~useful~~ to show a conventional 10 motherboard/daughterboard mounting configuration. Referring to Figure 1, there is shown such a conventional motherboard/daughterboard mounting configuration 10, wherein a plurality of daughterboards 12 are shown mounted to a single motherboard 14. Each daughterboard 12 has electronic 15 components 16 mounted thereon which are electrically connected to each other by signal conductors 18 in both the daughterboards 12 and the motherboard 14. The signal conductors 18 in the daughterboards 12 and the motherboard 14 are electrically connected via pin-and-box connectors 17. 20 That is, electrically conductive contact pads 22 on the daughterboards 12 are placed into electrical contact with

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groove 29 is illustrated, namely the one between conductors 26 and 27. The grooves 29 extend along the entire length of the copper conductors and are located equidistantly between the individual traces. The upper surface 24 of the PWB 11 is provided with a copper coating 28 which extends along the surfaces of the grooves 29 and into contact with the ground plane 25. Together with the ground plane 25, the copper coating 28 forms a complete shield around each signal conductor 26, 27. Via-in-pads 20 for connecting the conductors 26, 27 to the upper surface 24 of the PWB 11 are also shown for completeness.

These continuous electrically conductive shields described above are beneficial for reducing or eliminating cross-talk between signals propagating along adjacent signal conductors 26 and 27. These structures are also described in related U.S. Patent Application No. 09/443,128, filed November 18, 1999, which is incorporated by reference herein in its entirety.

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Thus, each signal conductor 26, 27 is enclosed by a continuous electrically conductive shield 28, except where openings 30 are formed in the top ground plane layer 24.

Figures 3A, 3B, and 3C illustrate a technique for connecting two PWBs 11 of the type shown in Figures 2A and 2B. The interconnect terminals/pads of PWB 11a and PWB 11b are mated together directly without a connector. Figure 3A is a perspective view showing the interconnection between the two PWBs 11a and 11b. Figure 3B is a top view of an interconnect of the invention and Figure 3C is a detailed cross section at interface a-a of Figure 3A. As most clearly shown in Figures 3A and 3B, an electrically conductive adhesive, solder paste, or interposer/elastomer device 31, 32 is used to connect a bottom ground plane 25a of PWB 11a to a top ground plane 24b of PWB 11b.

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A variety of techniques may be used for applying the solder paste to the ground planes, including, but not limited to (1) screen printing and (2) using a automatic dispensing machine. Screen printing is accomplished through the use of a stencil or screen through which adhesive or paste is applied to the terminal pads of the conductors. The volume of the paste or adhesive is determined by the mesh size of the stencil or screen. When a dispensing machine is used, the paste or adhesive is dispensed through a nozzle in the form of dots or a continuous line. The volume of the paste or adhesive is determined by the size of the nozzle, the number of dots dispensed, and the rheology of the dispensed compound.

When an interposer/elastomer device, such as a gasket for example, is used rather than solder paste or conductive adhesive, the interposer/elastomer device may also be positioned in the donut configuration 31, 32 as shown in Figures 3A and 3B or alternatively may be merely circular in shape. Therefore, the interposer/elastomer device has multiple points of contact with the conductors and electrically connects them.

However, the interposer/elastomer device does not secure the boards mechanically unless solder paste, mechanical clamps, or some other type of securing device is additionally used.

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signal conductors 46, 47. Plated copper shields 48 surround each differential pair, and together with the ground plane 45, form a complete shield around each differential pair of signal lines. In addition to the edge coupled representation depicted in Figures 4A and 4B, the invention may similarly be implemented with differential line pairs that are broadside coupled.

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Figs 5A and 5B illustrate the electrical interconnection of two PWBs 41a and 41b of the type illustrated in Figures 4A and 4B. A solder paste, conductive adhesive, or interposer/elastomer device 51, 52 is applied onto at least one of the ground planes 45a and 44b of the PWBs 41a and 41b. With the paste or adhesive, the ground planes 45a and 44b are mated together forming a hermetic conductive shield. As shown, a ring of solder paste or conductive adhesive 51 is applied around the openings 50 of both PWBs 41a and 41b. Additional solder paste or conductive adhesive 52 is applied to fill the via-in-pads 40 of the respective PWBs 41a and 41b. The use of an interposer/elastomer device is similar to that described above in connection with Figures 3A and 3B.

Referring to Figure 6, there is shown an embodiment of a motherboard/daughterboard interface configuration 100 in accordance with the present invention wherein a plurality of daughterboards 106 are shown interfacing with a single-sided
5 motherboard 102. All of the daughterboards 106 interface with the single-sided motherboard 102 in accordance with the present invention in the manner described herein.

The motherboard/daughterboard interface configuration 100 comprises a motherboard 102 having a plurality of signal
10 conductors 104 formed therein. The interface configuration 100 also comprises a daughterboard 106 also having a plurality of signal conductors 108 formed therein. The daughterboard 106 has an upper rigid portion 106a and a lower rigid portion 106b connected by a middle flexible
15 portion 106c. The signal conductors 108 are formed in and pass through all of these portions 106a, 106b, and 106c, as shown. The middle flexible portion 106c allows the upper rigid portion 106a to be substantially perpendicular to the motherboard 102 (as in conventional
20 motherboard/daughterboard mounting configurations), while allowing the lower rigid portion 106b to be substantially parallel to the motherboard 102. It should be noted that

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The lower rigid portion 106b of the daughterboard 106 comprises a bottom electrically conductive ground plane layer 124, a signal layer 126, and a buried electrically conductive ground plane layer 128. The signal layer 126 has the signal conductors 108 formed therein. The signal conductors 108 are surrounded by a dielectric material 130.

20 An electrically conductive paste or reflowed solder 151
may be applied in the vias between the openings 120 and 132
and the signal conductors 104 and 108 respectively. An

electrically conductive paste or reflowed solder 152 may
befurther applied surrounding the openings 120 and 132. The
paste or solder 152 is preferably applied on one or both
boards in a circular pattern. Alternatively, an
5 interposer/elastomer device may be used as described above.

The openings 120 formed in the top ground plane layer 112
of the motherboard 102 and the openings 132 formed in the
bottom ground plane layer 124 of the lower rigid portion
106b of the daughterboard 106 as well as the contact pads
10 within the openings are aligned.

Referring to Figure 7, there is shown an additional
embodiment of a motherboard/daughterboard interface
configuration 100 in accordance with the present invention
wherein a plurality of daughterboards 106 are shown
15 interfacing with a double-sided motherboard 102. All of the
daughterboards 106 interface with the double-sided
motherboard 102 in accordance with the present invention in
the manner described above.

At this point it should be noted that in all of the
20 above-described embodiments only one of the signal
conductors or neither of the conductors may have a shield
with an opening and the circuit boards may be positioned

such that the signal conductors are aligned through the opening and a signal propagating along a first signal conductor in a first circuit board is electrically connected to a second signal conductor in a second circuit board. If
5 neither of the conductors is shielded, some benefits are sacrificed, but the benefits derived from the absence of mechanical connectors are retained.

Figure 8 illustrates a cross-section of two PWB's 102 and 106 which have a horizontal interconnection. This
10 embodiment includes like reference numerals to the embodiments shown in Figures 6 and 7.

In view of the foregoing, it is apparent that the present invention provides a technique for electrically interconnecting signals between circuit boards wherein the
15 need for conventional mechanical connectors is totally eliminated. The elimination of conventional mechanical connectors results in the elimination of parasitics that are typically associated with conventional mechanical connectors, thereby resulting in better signal integrity.
20 Also, there are no longer any costs for purchasing connectors, as well as no assembly costs for mounting the connectors on a motherboard. Further, by incorporating the

shielding concept described in related U.S. Patent Application No. 09/443,128, filed November 18, 1999, which is incorporated by reference herein in its entirety, there is minimal or no unwanted signal cross-talk. Thus, the
5 present invention is particularly beneficial for high data rate applications.

The present invention is not to be limited in scope by the specific embodiments described herein. Indeed, various modifications of the present invention, in addition to those
10 described herein, will be apparent to those of ordinary skill in the art from the foregoing description and accompanying drawings. Thus, such modifications are intended to fall within the scope of the following appended claims. Further, although the present invention has been
15 described herein in the context of a particular implementation in a particular environment for a particular purpose, those of ordinary skill in the art will recognize that its usefulness is not limited thereto and that the present invention can be beneficially implemented in any
20 number of environments for any number of purposes.
Accordingly, the claims set forth below should be construed

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in view of the full breadth and spirit of the present
invention as disclosed herein.

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